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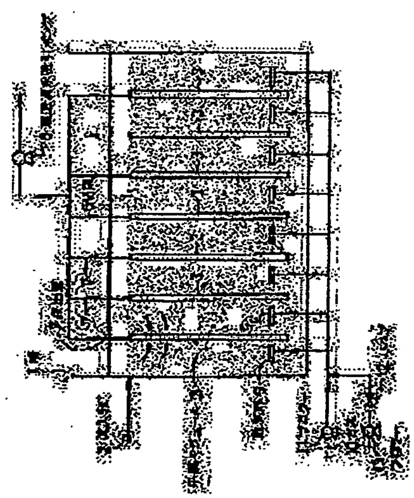
(54) MEMBRANE SEPARATION EQUIPMENT

(57)Abstract:
PURPOSE: To maintain filter resistance low for a long time and to provide a maintenance-free membrane separation equipment.
CONSTITUTION: The objective equipment consists of flat membrane modules 3 each of which is a filter medium consisting of a spacer 4 and a UF or MF membrane 5 (a planar separation membrane), a vessel 1 which is equipped with one or more flat membrane modules 3 and receives suspension liquid, and diffusing parts 9 of a diffuser arranged at the lower part of the flat membrane module 3 or at the lower side part of the filter medium. When the quantity of diffused air per hour from the diffuser is intermittently set large by a blower 11, a blower 13 and a valve 12, the movement of the suspension liquid is generated by gas 10, thus capable of maintaining the cleanness of the membrane surface.



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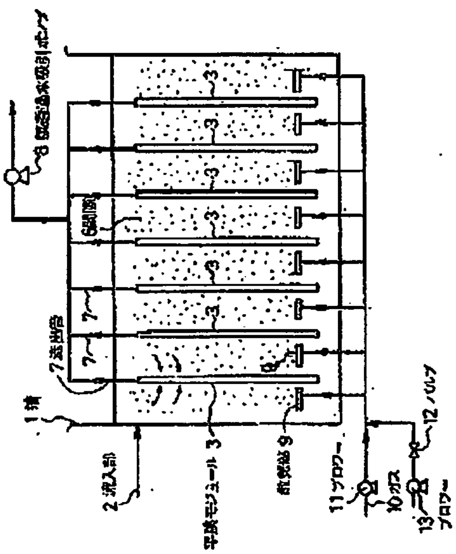
(54)【発明の名称】　膜分離装置

(57)【要約】

【目的】　本発明の目的は、濾過抵抗を長期間低く維持でき、かつメンテナンスフリーの膜分離装置を提供することある。

【構成】　本発明は、スペーサー４と平面状分離膜であるＵＦまたはＭＦ膜５とからなる濾過体である平膜モジュール３と、該平膜モジュール３を１以上配備し、かつ懸濁液を受け入れる槽１と、該平膜モジュール３の下方部または濾過体下部側方に配備された散気装置の散気部９とからなり、ブロワー１１およびブロワー１３とバルブ１２により散気装置からの単位時間当たりの散気ガス量を間欠的に大きく設定し、ガス１０により発生する懸濁液の運動により膜表面の清浄性を維持する。



【特許請求の範囲】

【請求項1】　スペーサーと平面状分離膜とからなる濾過体と、該濾過体を1以上配備し、かつ懸濁液を受け入れる槽と、該濾過体の下方部または濾過体下部側方に配備された散気部を有する散気装置とからなり、該散気装置からの単位時間当たりの散気ガス量を間欠的に大きく設定できる手段を備えたことを特徴とする膜分離装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、各種の任意の懸濁液（例えば、微生物粒子、無機物粒子等のサスペンション）を簡便に、効率的に膜分離し、清澄な分離液を得る膜分離装置に関するものである。

【0002】

【従来の技術】従来より、曝気槽内に中空糸膜の束状モジュールを浸漬し、透過液を得るようにした装置が公知である（図4参照）。

【0003】図4に示した装置は、曝気槽21内に中空糸膜モジュール22を浸漬し、散気管23から空気24を供給して槽内を好気性に維持して微生物の繁殖を確保すると共に中空糸膜の濾過機能を維持し、吸引ポンプ25により中空糸膜から微生物処理された槽内懸濁液の透過水26を得るものである。

【0004】しかしながら、本発明者がこの従来技術の追試を行ったところ、次のような重大欠点が認められ、実用性が欠けることが判った。即ち、図4に示したような装置では、次の問題がある。

【0005】①　活性汚泥、繊維分などのSS粒子が、中空糸膜の束の内部に入り込んで付着あるいは固着し、濾過抵抗が急増してしまう。②　中空糸膜の束の内部に入り込んだSS分は洗浄除去が極めて困難であり、中空糸膜モジュールを取り出して糸をほぐしながら高圧水でスプレーしないと付着汚泥、繊維分を洗浄除去できない。これは大変な手間であり、実用上このような作業を行うことは不可能である。

【0006】

【発明が解決しようとする課題】本発明は上記従来装置の重大欠点を完全に解決することを課題とするものであり、濾過抵抗を長期間低く維持でき、かつメンテナンスフリーの新技術を提供することを課題とする。

【0007】

【課題を解決するための手段】本発明は従来の技術の欠点を解決するために、種々検討した結果、次のような手段によって従来の欠点が解決できることを見出し完成された。

【0008】即ち、本発明はスペーサーと平面状分離膜とからなる濾過体と、該濾過体を1以上配備し、かつ懸濁液を受け入れる槽と、該濾過体の下方部または濾過体下部側方に配備された散気部を有する散気装置とからなり、該散気装置からの単位時間当たりの散気ガス量を間欠的に大きく設定できる手段を備えたことを特徴とする膜分離装置である。

【0009】本発明の新規思想は次の点にある。①　中空糸膜の採用をやめ、SSが束の内部にくいこむことが、形状的に有り得ない平面状分離膜を有する濾過体を適用する。

【0010】従来、平面状分離膜はフィルタプレス、脱水機的な構造体内に設置する方法は知られていたが、曝気槽体に、本発明のような方法で浸漬する概念は従来存在しなかった。

【0011】②　膜表面に乱れを与えるための散気量を間欠的に増減させると膜汚染を効果的に防止できることを見出した。本発明に使用される濾過体は、少なくともスペーサーと平面状分離膜とから構成される濾過部を有する。その濾過体の構造は、濾過部として少なくとも平面状分離膜外部で懸濁液を濾過し、該濾過水を該膜の内部へ移行する機能を有し、更に移行された濾過水を取り出す手段を備えていれば、特に濾過部の構成は制限されることはない。但し、濾過部の外部形状は濾過体を槽内に配備した時に、平面状分離膜表面全面が散気装置から供給される気泡および気泡による水流に接触し易い構造であることが好ましい。

【0012】該濾過部の外表面は、平面状分離膜で形成されるが、必ずしも該外表面全部を平面状分離膜で形成する必要はなく、適宜所望の表面領域を選択して部分的に形成することができる。

【0013】また、平面状分離膜の外表面の形状は、上記条件を満足するのであれば、特に制限されず、平面のみに限定されず、任意の曲面を包含できる。スペーサーは、平面状分離膜を支持すると共に濾過水の内部への移行を可能にするためのスペースを確保する機能を少なくとも有するのであれば、その構造は任意であり、特に制限されない。また、該移行された濾過水を外部へ取り出す手段、例えば、流出管をこれに具備させることもできる。

【0014】スペーサーの構成材料、具体的形状構造は任意であり、内部が充実した単体でも内部に空間を設けた単体でも、枠状でもあるいはこれらの組合せでもよい。例示すれば、枠状、内部の充実した単なる板状、内部に空間を設けた板状、格子状等が挙げられる。特に、構成材料としては、濾過機能を有する多孔体が好ましく、形状としては板状が特に好ましい。

【0015】スペーサーへの平面状分離膜の支持手段としては、接着剤、ボルト・ナット、磁石等が適用できる。従って、濾過体の濾過部の外部形状はスペーサーの形状と平面状分離膜のスペーサーへの保持方法によって決まるため任意であり、例示すれば、板状、柱状、逆円錐状等が挙げられる。特に、本発明では、板状が好ましく、両面を平面状分離膜で形成したものが好ましい。

【0016】該平面状分離膜の材料は清澄な濾過水が得

られれば、特に制限がなく、公知の限外濾過膜、精密濾過膜を使用でき、目的に応じて膜孔径を適宜選定すればよい。

【0017】本濾過体1体当たりの平面状分離膜の総面積は、通常、4～20m^2 の範囲から選択される。該濾過体は、本発明濾過装置内に配備されるが、その配備の位置等は特に限定されないが、同じく濾過装置内に配備される散気装置からの気泡および／または気泡による水流が平面状分離膜表面に衝突し易くなるように配置することが好ましい。特に、濾過体を複数個配備した場合には、各濾過体の平面状分離膜表面が垂直方向に対して平行になるようにかつ各平面状分離膜間の間隔が適切に設定されることが好ましく、同時に散気装置を濾過体の下方部または下部側方、例えば、各濾過体の間隙の下部に配備することが好ましい。

【0018】本発明に使用される散気装置は、ブロワー、管路、および散気部から概略構成されるが、通常使用されている公知ものが適用でき、特にその構造に制限はないが、散気部としては、管状、板状等が一般的である。

【0019】本発明は、散気装置からの散気ガスにより平面状分離膜の清浄性を維持するものであるが、その散気ガスの槽内へ供給する方法に特に制限はなく、供給量、供給時間、停止時間の設定等は懸濁液の種類、濾過体の種類、濾過水の基準等に応じて適宜選定される。

【0020】特に、本発明においては、単位時間当たりの散気ガス量を間欠的に大きく設定することにより、膜表面の清浄性をより高く維持できる特徴を有する。この場合、好ましくは、該大きく設定した時間帯（Gt）はその他の時間帯（Ct）よりも時間的に短くとることが好ましい。単位時間当たりの供給量はGt時の方がCt時に比べ大きく設定されるが、時間の経過に対して、通常、各々一定レベルを維持するが、各時間帯において増減あるいは供給停止も許容され得る。そして、散気管を複数使用した場合には各散気管において独立に供給仕様を設定してもよいし、各散気管を連絡して一律に設定してもよい。この設定の手段は任意であり、自動でも手動でもよく、例えば、ブロワー自体の制御、ブロワーとバルブの組合せ等が挙げられる。

【0021】また、散気ガスの種類は、本発明が適用される懸濁液の性状により適宜選択され、好気性生物処理液の場合は酸素含有ガス、例えば、空気が一般的であり、嫌気性生物処理液の場合は窒素ガスが挙げられる。これら処理液等の懸濁液は、外部から導入されたものであっても当初から本発明装置内で処理したものであって構わない。即ち、本発明は膜分離機能以外に汚水等の処理機能を有することは明白である。

【0022】本発明に適用される濾過方法は、平面状分離膜の外部、即ち懸濁液に接触する側から膜内部へ濾過水を移行する方法であるなら、任意の濾過圧発生手段が使用できる。例えば、濾過体内部をポンプで陰圧にすること、槽を密閉して槽内を陽圧にすること、サイホンを利用すること等が挙げられる。

【0023】濾過体を複数設けた時の濾過水集水機構は、各濾過体を個別に行っても各濾過体を連絡して行ってもよい。例えば、各スペーサーに濾過水流出管を設け、これを連絡して1個のポンプで吸引濾過する方法が挙げられる。

【0024】

【実施例】以下、図1を参照しながら本発明の作用と一実施例を説明する。図1において、1は任意の懸濁液が貯留された槽、2は懸濁液の流入部である。

【0025】本発明の膜分離装置は、槽1、濾過体である平膜モジュール3、および散気装置7から概略構成される。槽1内には、図2に示されるような板状多孔体のスペーサー4の両面に平面状UFまたはMF膜5を設けてなる平膜モジュール3が垂直方向に、間隙6を介して複数個、平行状に浸漬設置されている。

【0026】各々の濾過モジュール3からは膜透過水の流出管7が各々設けられている。該流出管5は、膜透過水吸引ポンプ8と連絡している。平膜モジュール3の下部には散気管または散気板からなる散気部9が設けられ、空気、その他のガス10をブロワー11によって散気させる。メタン発酵菌などの嫌気性微生物を膜分離する場合にはガス10として窒素ガス、メタンガスなどの酸素を含まないガスを使用する。

【0027】本発明において、ガス10の吐出量を間欠的に大きくさせるという概念は重要であり、一定量のガスを散気させる場合よりも効果的に膜汚染を防止でき、高い膜フラックスを長時間確保できることが実験的に確認された。

【0028】ガス10の流量を間欠的に大きくさせる手段は容易であり、任意の手段を適用できるが、図1の例ではブロワー13を設け、間欠的にバルブ12を開閉する方法を採用したものである。

【0029】なぜガス10の散気流量を間欠的に大きくさせると膜の汚染が効果的に防止できるのか、そのメカニズムの詳細は現時点で不明であるが、次のように推測できる。

【0030】即ち、ガス10の散気流量を間欠的に大きくすると平膜近傍の流れのフローパターンが激しく変化し、その際に膜表面の汚染物質が除去され、膜表面が清浄に保たれるのではないかと思われる。

【0031】ガス流量の大きさのパターンは種々変えることができるが、実験の結果では長時間の間隔をもたせてガス流量を大きくさせるよりも短時間のサイクルで大きくさせる方法の方が効果的であった。

【0032】つまり、例えば、6hrに1回30分間大きくさせるよりも、1hrに6分間大きくさせるサイクルのほうが効果的である。さらに、平膜モジュール3の

相隣接するモジュールの間隙6の距離は重要な因子であり、広すぎると膜汚染が進行し、狭すぎると夾雑物によって閉塞し易い。実験結果では10～30mmが最も好適であった。

【0033】また、散気装置9の設置方法もかなり重要な因子であり、図2のように平膜モジュールの横方向に散気管または板からなる散気部9を各々の間隙部6にそれぞれ設置する方法が最も好ましい。

【0034】この方法によれば、平膜モジュール3の各々の膜表面に確実に気泡の上昇による激しい水流の乱れを与えることができ、膜汚染を効果的に防止できる。本発明において使用する平膜分離膜の種類としては、UF膜（即ち、限外濾過膜）、MF膜（即ち、精密濾過膜）の各種のものを用いることができ、反応の種類、サスペンジョンの種類に応じて選定すればよい。

【0035】例えば、廃水処理、上水処理に適用する場合には、孔径0．01～1μm程度のMF膜を、また高度な処理を行う場合には、分画分子量が1000～100000程度のUF膜を用いることができる。

【0036】本発明の装置は微生物サスペンジョンの分離に好適であるが、河川水に硫酸アルミなどの凝集剤を注入して、生成フロックを分離するにも好適である。実験例

本発明を下水の活性汚泥処理を行う装置として、本発明の性能の実証実験を行った。

【0037】横30cm、縦40cm、高さ70cmの水槽にMLSS3500mg／lの活性汚泥スラリーを満たし（水位50cm）、下記の平膜モジュールを垂直方向に2枚浸漬した。

【0038】平膜モジュール仕様：

大きさ：15×15cmの正方形のMF膜

膜孔径：0．5μm

スペーサー；孔径150μmのプラスチック多孔体（板状）

散気空気量：散気管から吐出させる空気量を次のサイクルで増減。

【0039】100リットル空気／分を30分

その後、300リットル空気／分を3分

その後、100リットル空気／分に減少させて30分

というサイクルを繰り返す。

【0040】この条件で6ヶ月運転を続けたところ、膜透過fluxは図3の線aのようになった。この実験の間、薬品による膜の洗浄は一度も行わなかった。

【0041】また、図の線bは、空気量の散気流量を100リットル／分一定で行った場合の結果を示す。明らかに空気の間欠的増減法がfluxを高く保つのに有効である。

【0042】また、本発明の濾過体に使用される膜は平面状であるため、中空糸膜束状モジュールのような内部へのSSのくいこみ、固着は全く認められず、メンテナンスフリーであった。

【0043】

【発明の効果】① 中空糸膜法のような膜面へのSS、汚泥、繊維分の固着がなく、メンテナンスフリーの操作が可能である。

【0044】② 膜の透過fluxを長期間、高い値に安定して維持できる。③平膜をスペーサーにとりつけて、単にタンクに浸漬するだけなので、装置、製作が簡単で製作費も安価である。

【0045】④ 万一、予測できないトラブルによる膜汚染が発生し、透過fluxが低下した場合でも平膜モジュールをつり上げて、高圧水でスプレーするだけで、容易に洗浄できる。中空糸膜法では、中空糸を一本一本ほぐさないと洗浄できないので、人手でないと実施できないし、大変な手間がかかる。

【0046】⑤ 膜面が平板状なので気泡による水流の乱れを各々の膜面に対し、確実に与えることができる。中空糸膜では一本一本の中空糸膜の表面に均等に乱れを与えることは不可能である。

【0047】この結果、極めて膜汚染が発生しにくい。

【図面の簡単な説明】

【図1】本発明の膜分離装置の一例を説明するための図である。

【図2】本発明に使用される濾過体の一例を示す斜視図である。

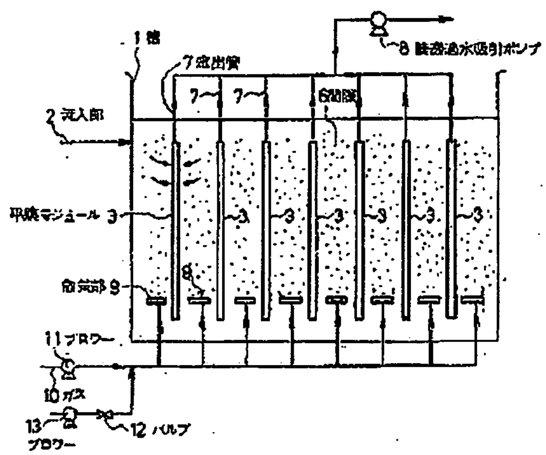
【図3】本発明の装置を用いた実験例の結果を示すグラフである。

【図4】従来の膜分離装置の一例を説明するための図である。

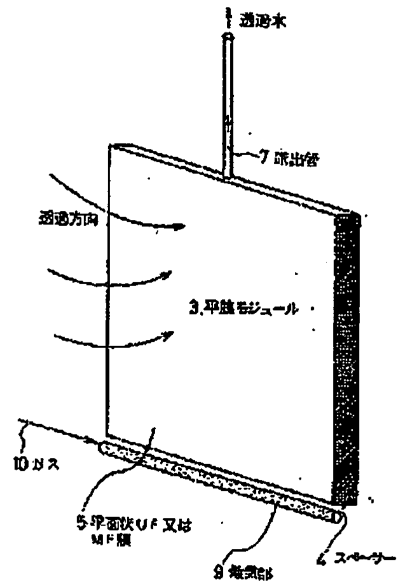
【符号の説明】

1 槽
2 流入部
3 平膜モジュール
4 スペーサー
5 平面状UF又はMF膜
6 間隙
7 流出管
8 膜透過水吸引ポンプ
9 散気部
10 ガス
11 ブロワー
12 バルブ
13 ブロワー
21 曝気槽
22 中空糸膜モジュール
23 散気管
24 空気
25 吸引ポンプ

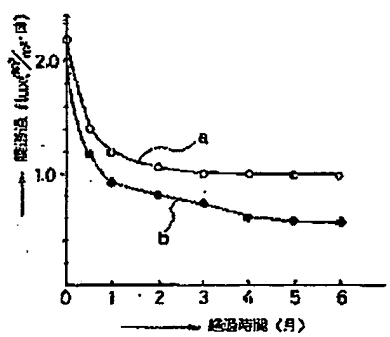
【図1】


1 槽
7 流出管
8 膜透過水吸引ポンプ
7
7
6 間隙
2 流入部
平膜モジュール 3
3
散気部 9
8
11 ブロワー
10 ガス
13
ブロワー
12 バルブ

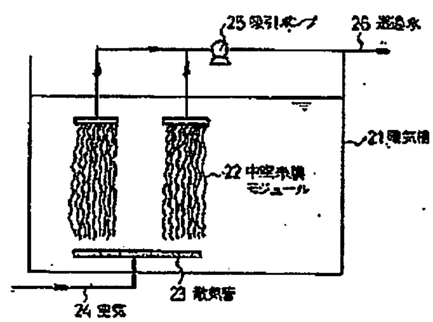
【図2】


透過水
7 流出管
透過方向
3 平膜モジュール
10 ガス
5 平面状UF又は
MF膜
9 散気部
4 スペーサー

【図3】


膜透過 flux(m³/m²·日)
2.0
1.0
a
b
0
1
2
3
4
5
6
経過時間（月）

【図4】


25 吸引ポンプ
26 透過水
21 曝気槽
22 中空糸膜
モジュール
23 散気管
24 空気

EUROPEAN PATENT O ICE

Patent Abstracts of Japan

PUBLICATION NUMBER : 04265128
PUBLICATION DATE : 21-09-92

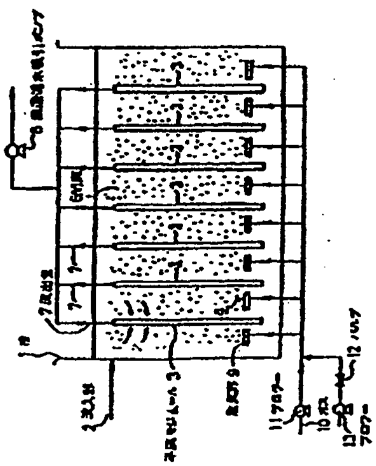
APPLICATION DATE : 20-02-91
APPLICATION NUMBER : 03026397

APPLICANT : EBARA RES CO LTD;

INVENTOR : KATAOKA KATSUYUKI;

INT.CL. : B01D 63/08 B01D 65/02 C02F 3/12

TITLE : MEMBRANE SEPARATION EQUIPMENT



ABSTRACT : PURPOSE: To maintain filter resistance low for a long time and to provide a maintenance-free membrane separation equipment.

CONSTITUTION: The objective equipment consists of flat membrane modules 3 each of which is a filter medium consisting of a spacer 4 and a UF or MF membrane 5 (a planar separation membrane), a vessel 1 which is equipped with one or more flat membrane modules 3 and receives suspension liquid, and diffusing parts 9 of a diffuser arranged at the lower part of the flat membrane module 3 or at the lower side part of the filter medium. When the quantity of diffused air per hour from the diffuser is intermittently set large by a blower 11, a blower 13 and a valve 12, the movement of the suspension liquid is generated by gas 10, thus capable of maintaining the cleanness of the membrane surface.

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Examination Request	Not yet made

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C02F 3/12		S	9153-4D		

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(21) Application No: 3-26397
(22) Application Date: February 20. 1991
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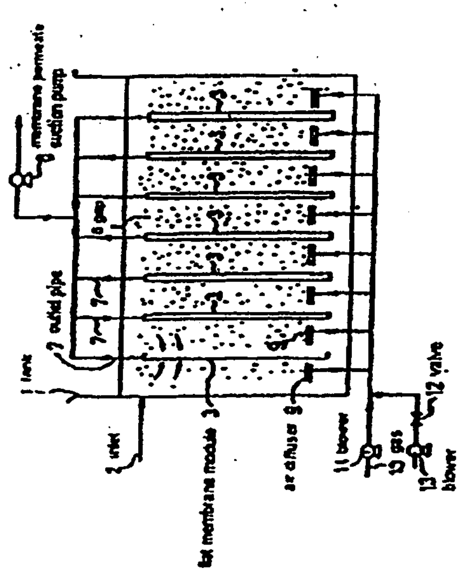
(74) Agent: Patent Attorney, HAGINO, Taira
Three others

(54) [Title of the Invention] Membrane Separation Device

(57) [Abstract]
[Object] An object of the present invention is to provide a membrane separation device that can maintain low filtration resistance over a long period of time and that is maintenance free.

[Constitution] The present invention comprises a flat membrane module 3, which is a filter body comprising a spacer 4, and a flat separation membrane that is a UF or MF membrane 5; a tank 1 in which no less than one said flat membrane module 3 is disposed, and which receives a liquid suspension; and a diffuser member 9 of a diffusion device disposed below said flat membrane module 3, or below and to one side of said filter body; an intermittently greater flow of diffused gas from diffusion device per unit of time is established by a blower 11, a blower 13, and a valve 12, and the membrane surface is maintained clean by the action of the liquid suspension generated by the gas 10.



USF 134785

[Claims]

[Claim 1] A membrane separation device characterized in that this comprises: a filter body comprising a spacer and a flat separation membrane: a tank in which no less than one said filter body is disposed, and which receives a liquid suspension; and a diffusion device having a diffuser member disposed below said filter body, or below and to one side of said filter body, [the membrane separation device] being provided with means for establishing an intermittently greater flow of diffused gas from said diffusion device per unit of time.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Application] The present invention relates to a membrane separation device capable of providing simple and effective membrane separation of various freely selected suspensions (for example, suspensions of microbiological particles, inorganic particles, and the like), so as to produce a clarified separated liquid.

[0002]

[Prior Art] Conventionally, devices are known wherein a permeate is produced by immersing a hollow-fiber membrane bundle module in an aeration tank (see FIG. 4).

[0003] The device shown in FIG. 4 is such that a hollow-fiber membrane module 22 is immersed in an aeration tank 21; air 24 is supplied from an air diffusion pipe 23 so as to maintain growth of microorganisms by keeping the interior of the tank aerobic while maintaining the filter function of the hollow-fiber membrane; a suction pump 25 is used to obtain permeate 26 from the suspension within the tank which has been microbiologically processed.

[0004] However, when the present inventors did additional tests on this prior art, they found the following serious disadvantages and judged the practicality thereof to be inferior. That is to say, the device shown in FIG. 4 has the following disadvantages.

[0005] (1) SS particles, such as activated sludge or fibrous components, get into the hollow-fiber membrane bundles and adhere or become affixed thereto, causing the filtration resistance to rise sharply. (2) Washing away SS components which have gotten into the interior of the hollow-fiber membrane bundles is extremely difficult; it is not possible to wash away the adherent sludge and fibrous components without removing the hollow-fiber membrane module, undoing it, and spraying it with high-pressure water. This is extremely labor-intensive, and it is practically impossible to implement these operations.

[0006]

[Problems to Be Solved by the Invention] The present invention is directed at completely solving the major problems of the conventional devices described above; an object thereof is to provide a novel technology which can maintain low filtration resistance over a long period of time, and which is maintenance-free.

[0007]

[Means for Solving the Problems] In order that the present invention solve the problems of the prior art, various studies were conducted, and as a result, it was discovered that the conventional problems could be solved by the following means, and [in this manner] the present invention was completed.

[0008] That is to say, the present invention is a membrane separation device characterized in that this comprises: a filter body comprising a spacer and a flat separation membrane, a tank in which no less than one said filter body is disposed, and which receives a liquid suspension; and a diffusion device having a diffuser member disposed below said filter body, or below and to one side of said filter body, [the membrane separation device] being provided with means for establishing an intermittently greater flow of diffused gas from said diffusion device per unit of time.

[0009] The following are novel ideas of the present invention. (1) The use of hollow-fiber membranes is abandoned; a filter body is used having a flat separation membrane wherein the shape makes it impossible for suspended solids to become trapped at the interior of bundles.

[0010] Conventionally, methods wherein flat separation membranes were provided in filter presses and dehydrator structures were known, but the idea of immersing these in an aeration tank as part of a method such as that of the present invention has never before existed.

[0011] (2) It was discovered that it was possible to effectively prevent membrane soiling by intermittently increasing and decreasing the amount of diffused gas so as to create a disturbance at the membrane surface. The filter body used in the present invention has a filter member comprising at least a spacer and a flat separation filter. There are no particular restrictions on the construction of this filter member, so long as the construction of the filter member functions so that a suspension is filtered at least at the exterior of a flat separation membrane so that the filtrate moves to the interior of this membrane, and this is further provided with means for removing the filtrate that has been moved. However, the exterior shape of the filter member is preferably such that, when the filter body is disposed within the tank, the entire surface of the flat separation membrane can easily be contacted by bubbles supplied from the diffusion device and by the currents caused by the bubbles.

[0012] The exterior surface of this filter member is formed as a flat separation membrane, but it is not absolutely necessary that the entire exterior surface be formed as a flat separation membrane; this can be formed locally on a suitable desired surface region.

[0013] Furthermore, so long as the form of the exterior surface of the flat separation membrane satisfies the aforementioned conditions, there are no particular restrictions thereon; this is not limited to flat surfaces; and freely chosen curved surfaces are encompassed thereby. So long as the spacer functions at least to support the flat separation membrane while maintaining a space which allows the filtrate to move to the interior, the construction thereof may be freely chosen, and there are no particular restrictions thereon. Furthermore, means for removing the filtrate which has moved to the interior, such as an outlet pipe, can be provided.

[0014] The material from which the spacer is constructed and the specific shape of the construction may be freely chosen; this can be a simple body with a solid interior or a simple body with a hollow interior, or a frame, or a combination of these. Examples include a frame, a simple plate with a solid interior, a plate provided with a hollow interior, a lattice, etc. In terms of the construction material, a porous material having a filter function is particularly preferable, and in terms of the shape, a plate is particularly preferable.

[0015] In terms of the means for supporting the flat separation membrane on the spacer, adhesives, nuts and bolts, magnets, and the like can be used. Accordingly, the external shape of the filter member of the filter body can be freely determined according to the shape of the spacer and the method of holding the flat separation membrane against the spacer. examples include plates, rods, inverted cones, and the like. In the present invention, plates are particularly preferred, and those wherein a flat separation membrane is formed on both sides are preferred

[0016] There are no particular restrictions on the material for the flat separation membrane.

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so long as this can produce a clarified filtrate: well-known ultrafiltration membranes and microfiltration membranes can be used, and the pore size of the membrane may be freely chosen as suitable according to the objective.

[0017] The total surface area of the flat separation membrane for one of these filter bodies is normally chosen from within the range of 4-20 m². The filter body is disposed within the filter device of the present invention, but there are no particular restrictions on the position at which this is disposed or the like; it is preferable that this be positioned so that the flat separation membrane is readily impacted by the bubbles and/or the currents created by the bubbles from the diffusion device, which is also installed within the filter device. In particular, if a plurality of filter bodies are installed, it is preferable that the flat separation membrane surfaces of the filter bodies be parallel to the perpendicular direction, and that a space be suitably provided between each of the flat separation membranes; meanwhile, it is preferable that the diffusion device be installed below the filter body, or below the filter body and to one side, for example, at the bottom of the gap between the filter bodies.

[0018] The diffusion device used in the present invention has a basic structure comprising a blower, a conduit, and a diffuser member, but commonly used well-known devices can be used, and while there are no particular restrictions on the structure thereof, pipes and plates are generally used as the diffuser member.

[0019] The present invention maintains the flat separation membrane clean by means of the gas diffused from the diffusion device, but there are no particular restrictions on the method of supplying this diffused gas to the interior of the tank; the settings for the amount supplied, the supply time, the stop time, and the like can be suitably chosen according to the type of suspension, the type of filter body, the standards for the filtrate, and the like.

[0020] In particular, the present invention is characterized in that the membrane surface can be maintained at a greater level of cleanliness by intermittently establishing a high flow rate of diffused gas per unit of time. In this case, it is particularly preferable that the period of time for which the high flow rate is established (Gt) is shorter than the other period of time (Ct). The amount supplied per unit of time in the Gt time is greater than that in the Ct time, and each of these amounts is normally maintained at a constant level over time, but increasing or decreasing this or stopping the supply in either of the time periods is acceptable. Next, if a plurality of diffusion pipes are used, this may be set up so that each of the diffusion pipes is supplied independently, or the diffusion pipes may be connected and supplied together. The means used for these setups may be freely chosen, and these may be automatic or manual; examples include control of the blower itself or combinations of a blower and a valve, or the like.

[0021] Furthermore, the type of diffused gas may be suitably chosen according to the properties of the suspension used in the present invention; in the case of an aerobic biological processing liquid, gasses containing oxygen, such as air, are commonly used; in the case of an anaerobic biological processing liquid, nitrogen gas may be used. Suspensions such as these processing liquids may be introduced from the exterior or may be processed within the device of the present invention from the beginning. In other words, it is clear that, in addition to membrane separation functions, this invention may have other processing functions for polluted water and the like.

[0022] While the filtration method used in the present invention is a method that moves filtrate from the exterior of the flat separation membrane, which is to say, from the side in contact with the suspension, to the interior of the membrane, freely chosen filter pressure generation means may be used. For example, a negative pressure may be generated within the filter body by means of a pump, the tank may be sealed and the interior of the tank may be positively pressurized, a siphon may be used, etc.

[0023] When a plurality of filter bodies are provided, the filtrate recovery mechanism may be such that this is performed separately for each filter body, or this may be performed with the filter bodies connected. For example, methods include those wherein a filtrate outlet pipe is provided at each spacer, these are connected, and suction filtration is performed by means of a pump.

[0024]

[Embodiments]

In the following, the operation of the present invention and one embodiment thereof are described with reference to FIG. 1. In FIG. 1, 1 is a tank filled with a freely chosen suspension, and 2 is a suspension inlet.

[0025] The basic construction of the membrane separation device of the present invention comprises a tank 1, a flat membrane module 3 which is the filter body, and a diffusion device 7 [sic]. Within the tank 1, a plurality of flat membrane modules 3, wherein a flat UF or MF membrane 5 is provided on both sides of a planar porous body spacer 4, as shown in FIG. 2, is immersed and disposed parallel to the perpendicular direction with gaps 6 therebetween.

[0026] Membrane permeate outlet pipes 7 are provided at each of the filter modules 3. The outlet pipe 5 [sic] is connected to a membrane permeate suction pump 8. Diffuser members 9, made from a diffusing pipe or a diffusing plate, are provided at the bottoms of the flat membrane modules 3; air or another gas 10 is diffused by means of a blower 11. If methane fermentation bacteria, or such anaerobic microorganisms, are to be membrane separated, a gas not containing oxygen, such as nitrogen gas or methane gas, is used as the gas 10.

[0027] In the present invention, the idea of intermittently increasing the amount of gas 10 blown is important; membrane soiling can be prevented more effectively than in the case where gas is diffused at a constant rate; and, it has been experimentally confirmed that this allows for maintenance of a high membrane flux for a long period of time.

[0028] The means for intermittently increasing the rate of flow of the gas 10 are simple and any means can be used but, in the example of FIG. 1, a method is adopted wherein a blower 13 is provided, and a valve 12 is intermittently opened and closed.

[0029] In terms of why soiling of the membrane can be effectively prevented by intermittently increasing the rate at which the gas 10 is diffused, that mechanism is not understood in detail at the present time, but it is presumed to be as follows.

[0030] That is to say, it is thought probable that, if the rate at which the gas 10 is diffused is intermittently increased, the flow patterns of the currents in the vicinity of the flat membrane are radically altered, and soiling substances on the membrane surface are removed at this point, so that the membrane surface is kept clean.

[0031] It is possible to change the pattern of the rate of flow of the gas in various ways, but experimental results indicate that a method wherein this is increased in short time-period cycles is more effective than one wherein the rate of flow of the gas is increased over long intervals of time.

[0032] In other words, for example, it is more effective to have cycles with increased flow for 6 minutes in 1 hour than to have increased flow for 30 minutes once every 5 hours. Moreover, the size of the gap 6 between a flat membrane module 3 and an adjacent module is an important factor. if this is too wide. soiling of the membrane will progress. and if this is too narrow. this is readily obstructed by foreign matter. Experimental results show that 10-30 mm is optimal.

[0033] Furthermore, the disposition of the diffusion device 9 [sic] is also quite an important factor. most preferably. a diffuser member 9, comprising a diffusing pipe or plate, is installed in each gap 6 to the side of the flat membrane module, as shown in FIG. 2.

[0034] By virtue of this method, it is possible to radically disturb the water currents created by the rising bubbles at the surface of each membrane of the flat membrane modules 3 in a reliable manner, so as to effectively prevent membrane soiling. In terms of the type of flat-membrane separation membrane used in the present invention, various types of UF membranes (which is to say ultrafiltration membranes) and MF membranes (which is to say microfiltration membranes) can be used: these may be selected in accordance with the type of reaction and the type of suspension.

[0035] For example, if this is applied to wastewater treatment or water supply treatment, a microfiltration membrane with a pore size of approximately 0.01-1 μm can be used, and if high-level treatment is to be performed, UF membranes with a molecular weight cutoff of approximately 1000-100,000 can be used.

[0036] The device of the present invention is suitable for separation of microbiological suspensions, but it is also suitable for separating formed flock when coagulation agents, such as aluminum sulfate, are added to river water.

Experimental Examples

The performance of the present invention was proved experimentally using the present invention as a device for activated sludge processing of sewage.

[0037] A water tank having a width of 30 cm, a length of 40 cm, and a height of 70 cm was filled with a slurry of MLSS 3500 mg/liter activated sludge (water level 50 cm) and two of the following flat membrane modules were immersed in the perpendicular direction.

[0038] Flat membrane module specifications:
size: 15 x 15 cm^2 MF membrane
membrane pore size: 0.5 μm
spacer: plastic porous body with a pore size of 150 μm (plate)
rate of diffusion: amounts of air blown from the diffuser pipe are increased and decreased in the following cycles.

[0039] Cycles were repeated as follows:
100 liters air/minute for 30 minutes
thereafter, 300 liters of air/minute for 3 minutes
thereafter, reduced to 100 liters of air/minute for 30 minutes.

[0040] Operations were continued for six months under these conditions, and the membrane permeate flux was as shown by line a in FIG. 3. During this experimental period, the membrane was never washed with chemicals.

[0041] Furthermore, line b in the figure indicates results for a case where the rate at which the air was diffused was fixed at 100 liters/minute. It is clear that intermittently increasing and decreasing the amount of air was effective in maintaining high flux.

[0042] Furthermore, as the membrane used as the filter body in the present invention was flat, absolutely no clogging or adherents of suspended solids within the hollow-fiber membrane bundle module was observed, and this was maintenance-free.

[0043]

[Effects of the Invention] (1) There was no adhesion of suspended solids, contaminants, or fiber components on the membrane surface: such was the case with the hollow-fiber membrane method, allowing for maintenance-free operation.

[0044] (2) It was possible to maintain the membrane permeate flux at a stably high value over a long period of time. (3) The flat membrane is simply attached to a spacer and immersed in a tank, so that the device and the manufacture thereof are simple, and the manufacturing costs thereof are low.

[0045] (4) Meanwhile, even in cases where unexpected trouble results in soiling of the membrane and a drop in permeation flux, the flat membrane module can simply be pulled out and easily cleaned with a high-pressure water spray. With the hollow-fiber membrane method, cleaning was not possible without undoing the hollow fibers one by one, which could not be done except by humans and was extremely labor-intensive.

[0046] (5) As the membrane surface is planar, each of the membrane faces can reliably receive the disturbances in flow caused by the bubbles. With hollow-fiber membranes, it would not be possible to provide the disturbance uniformly to the surfaces of the hollow-fiber membranes one by one.

[0047] Consequently, soiling is extremely unlikely to occur.

[Brief Description of the Drawings]

[FIG. 1] This figure serves to describe an example of a membrane separation device of the present invention.

[FIG. 2] This is a perspective view illustrating one example of a filter body used in the present invention.

[FIG. 3] This is a graph showing the results of an experimental example using the device of the present invention.

[FIG. 4] This is a figure for the purpose of describing one example of a conventional membrane separation device.

[Explanation of the Reference Numerals]

1 tank
2 inlet
3 flat membrane module
4 spacer
5 flat UF or MF membrane
6 gap
7 outlet pipe
8 membrane permeate suction pump
9 diffuser
10 gas
11 blower
12 valve
13 blower
21 aeration tank
22 hollow-fiber membrane module
23 diffusion pipe
24 air
25 suction pump

FIG. 1

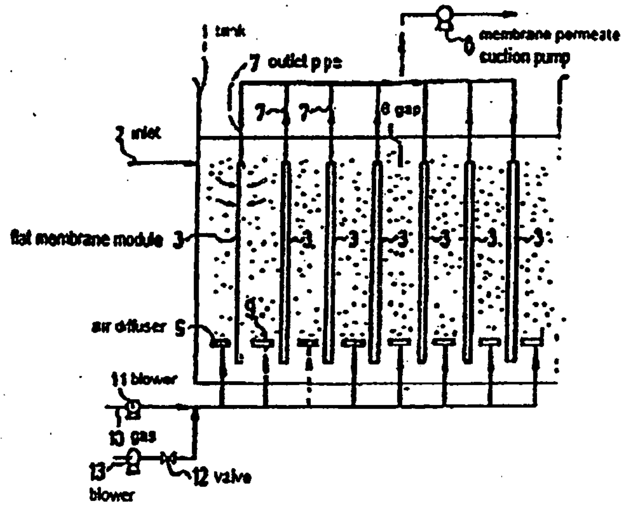

FIG. 2

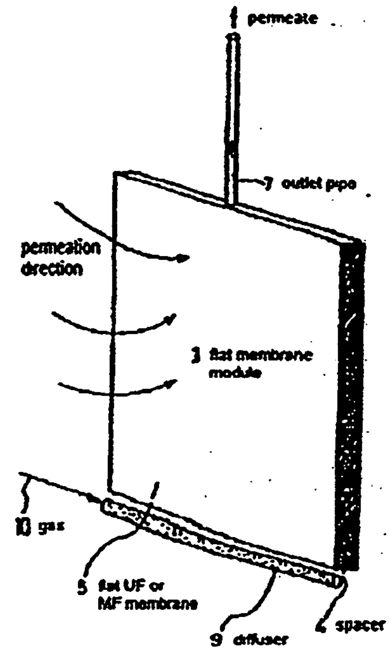

FIG. 3

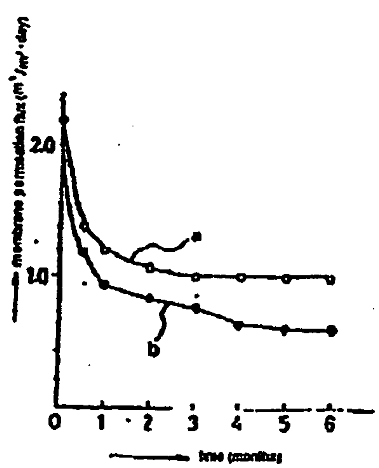

FIG. 4